Forested Vegetation – Fragmentation

This paper summarizes general information on the topic of fragmentation and reviews what we currently know about fragmentation on the Bighorn NF. This information will be used for Forest Plan revision.

Forests change all the time under natural disturbance regimes. Fire, wind, insects and diseases, and native ungulates are the natural, non-human, disturbances that most affected the Bighorn mountain landscape. Pre-European man also affected the landscape by using fire, and to lesser degree, limited tree cutting and rock quarrying. Typically, when determining a “baseline” for current fragmentation analyses, native American influences are included as “natural” events.

Fragmentation can be described as “human caused discontinuities” in natural landscapes, and is a sweeping term for a host of processes (Knight et al, 2000). Fragmentation can be caused by roads, timber harvest, land ownership patterns, subdivisions, homes, and agricultural practices such as croplands. Dams and culverts, among other things, can cause fragmentation in aquatic systems, but this paper will only deal with terrestrial fragmentation influences. On the Bighorn National Forest, the primary causes of fragmentation identified to date have been roads and timber harvest (Tinker, et al 1998).

Much of the early work on fragmentation began in forest systems other than the Rocky Mountains, such as in the eastern hardwood forests. These analyses typically involved permanent land use changes, such as changing forests to crop land or urban areas. These practices isolate small remnants of the original hardwood forest matrix and create hostile environments between patches. The result was that some species were isolated and some species suffered increased predation.

While roads might be a “permanent” land use change, timber harvesting as practiced on the Bighorn NF does not create a permanent land use change. Timber harvests maintain the land in a *forested* condition, but they can set the forest back successionally to a temporary grass-forb stage. While timber harvest differs in many ways from fire, the major pre-European influence on the Bighorn NF landscape, fire had a similar successional affect.

REVIEW OF BIGHORN SPECIFIC FRAGMENTATION WORK

Beauvais (1997) summary on small mammals

- Species richness of mammals in winter did not change along the major micro- and macro- gradients produced by clearcutting. However habitat changes accompanying clearcutting allowed common habitat generalists (elk, weasels, bobcats, coyotes, montane voles, deer mice, least chipmunks) to replace rarer, boreal adapted species (moose, southern re-backed voles, masked shrews, dusky shrews, showshoe hare, red squirrels, marten).
- Shrews, southern redbacked voles, moose, and martens are strongly associated with undisturbed, late successional forests. These species occurred most often in spruce-fir stands with large trees and dense coarse woody debris and in landscapes dominated by spruce-fir forest and low density of forest edge.

Merrill (1997)summary on birds

- Merrill (1997), studied avian diversity and species richness at a variety of scales, from 6 to 3600 ha. Sampled breeding birds at >2700 sites in Bighorn NF during May-July of 1994 and 1995.
- Avian diversity and richness not strongly tied to the extent of any individual cover type.
- Strongest relationships were found in aspen and willow.
- Avian diversity highest in landscapes with a heterogeneous mix of forest and open habitats.
- Extent of early seral forests positively related to species richness at the 900 and 3600 ha scales, but only significant at 900 ha scale. This effect was due to a few landscapes with a high proportion of natural burns (>400 has).
- Species richness in areas with a high proportion of clearcuts (i.e. >100 ha/900ha landscape) were either average or below average for the landscape.
- Elevation was negatively related to richness and diversity at all but the largest scale.
- Out of 36 tests, there were only 2 significant effects due to patch configuration:
    - At 900 ha scale, species richness was higher at sites which had higher than average values in forest patch shape/edge density.
    - At 225 ha scale, species richness was higher in areas where forest patches were less isolated when the landscape was dominated by open grassland/shrubland but that species richness was lower in areas where forest patches were less isolated patches when forest dominated the environment.
- One of their conclusions was that "…landscape heterogeneity was generally a more important indicator of bird diversity in the [Bighorn National Forest] at the scales we studied than indices related to patch size or isolation or edge characteristics."

Tinker et al, 1998 summary on quantifying fragmentation

Another disturbance measure that quantifies the amount of disturbance in this watershed is found in Tinker, et al. 1998. This paper summarizes a fragmentation analysis, and quantifies the change in landscape parameters due to road construction and logging. A host of landscape parameters were quantified, including core area, size of patches, patch shapes, core area per patch. “Fragmentation” is considered by Tinker, et al., to be phenomenon of breaking up large, contiguous patches of forested area that features large areas of core habitat into smaller pieces that feature more edge habitat and less interior forest habitat.

The procedure for this analysis was:

1. The first map, BASE, was constructed by using the Game and Fish satellite cover type map and “adding back” clearcuts and subtracting roads.
2. BASERD was the same as BASE except that it added existing roads.
3. BASECT was the same as BASE except that it added existing clearcuts.
4. The final map BASECTRD was the same as base, but added both existing roads and clearcuts.

Some summary interpretations include:

1. In spruce-fir cover types, watersheds 2,3,8,9, and 12 have had the amount of core habitat decreased. Roads and clearcuts in watersheds 1,4,5,6,7,10 and 11 have had little to no effect upon the spruce-fir core area (component #1).
2. In lodgepole cover types, watersheds 1,5,6, and 12 have had little change in the amount of core habitat, while the other watersheds have decreased amount of core habitat (component #1).
3. Tinker, et al, quantified landscape changes, but did not correlate that to species effects.

Concerning fragmentation, as described by Tinker, et al, it is important to note that most Rocky Mountain National Forests purposefully “fragmented” forests in the 1980’s. The dominant timber harvest prescription throughout the Region in the late 1980’s, creating 5-20 acre clearcuts in old, unharvested forested areas, was designed to maximize the amount of edge and forage in order to improve elk habitat. Within a decade, the importance of patch size, amount of contiguous forest, core habitats began to be recognized. A lesson here is that our management objectives and learning about habitat effects change faster than our forests, and previous well designed, well implemented projects have been criticized later based upon changing objectives and increased scientific knowledge.

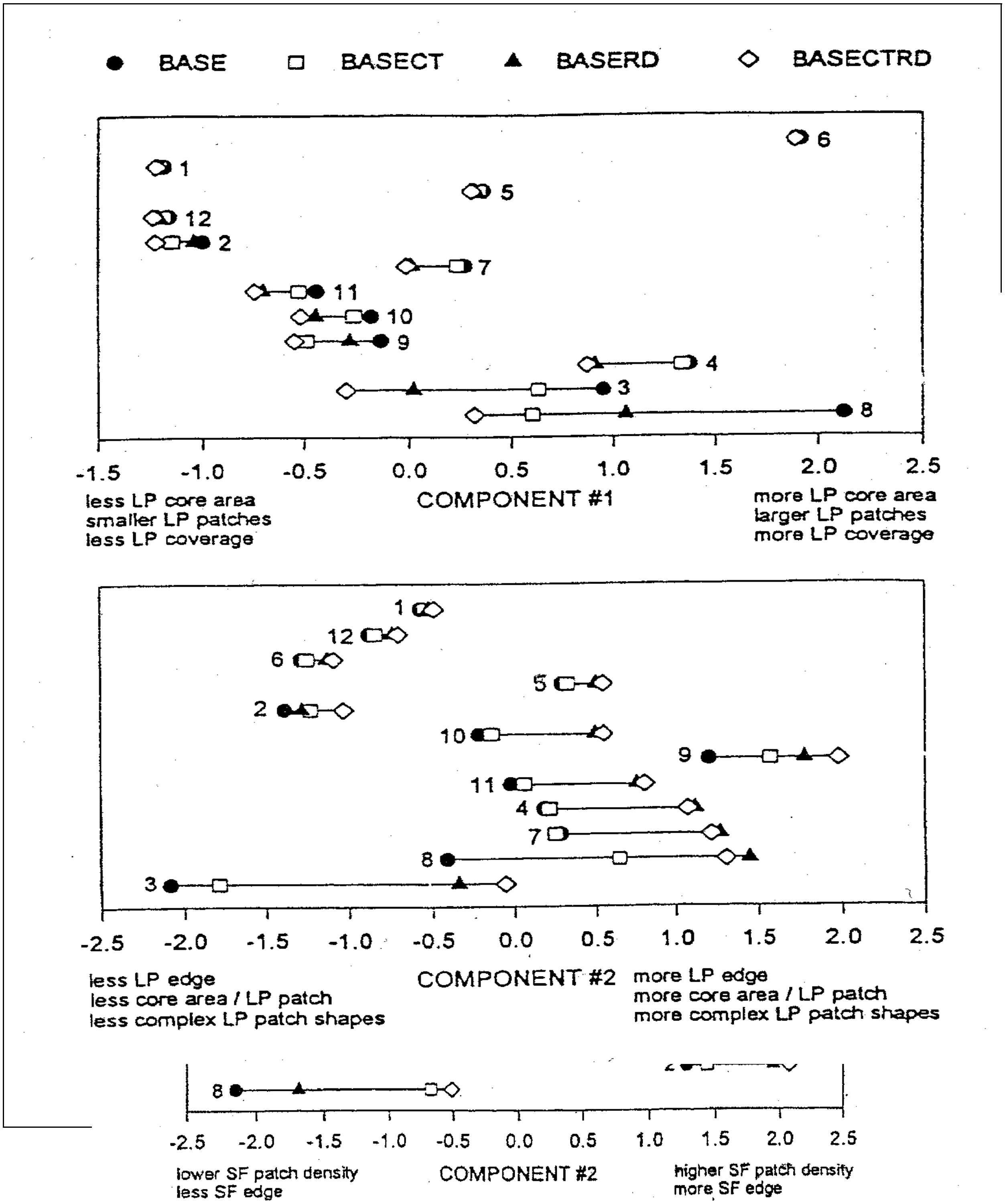

Figure 42. Scores on the first two principal components of spruce-fir forest (SF) variables for each watershed on the Bighorn National Forest. The components are correlated to several landscape variables indicated on the bottom of graph. Numbers adjacent to the symbols indicate watershed number. The symbols represent each type of map analyzed. BASE = map with no human disturbances, BASECT = rnap with clearcuts added, BASERD = map with roads added, BASECTRD = map with roads and clearcuts added.

Key to Watersheds

Tinker, et al. Number	Name
1	Devil's Canyon
2	Little Bighorn
3	Tongue River
4	Goose Creek
5	Piney Creek
6	Rock Creek
7	Clear Creek
8	Crazy Woman Creek
9	North Fork Powder River
10	Tensleep Creek
11	Paintrock Creek
12	Shell Creek

Fragmentation Generally in the Southern Rocky Mountains

The following summarizes some information from Knight, et al (2000).

Chapter	Authors	Key Findings
1	Buskirk, Romme, Smith, R.L.Knight	Overview of Fragmentation in Southern Rocky Mountains. Definitions, context, evolution of thought.
2	D.H. Knight, Reiners	Natural Patterns in Southern Rocky Mountain Landscapes and Their Relevance to Forest Management. Three conclusions: a. Place high value on remaining homogeneous tracts of interior forests. b. Scientists and managers should work together to identify ecosystems most at risk. c. Current timber harvest should strive to maintain biological diversity and soils.
3	Veblen	Disturbance Patterns in Southern Rocky Mountain Forests. Key descriptors of a disturbance regime: 1. Spatial distribution 2. Frequency 3. Size of area disturbed 4. Mean return interval 5. Predictability 6. Rotation period 7. Magnitude of severity 8. Synergies with other disturbances Review of fire, insects, wind, and climatic influences on those disturbance agents. "Due to the long fire intervals typical of subalpine forests, the past approximately 80 years of fire suppression have not necessarily had much influence on rates of fire recurrence in some areas of subalpine forests." "…fire suppression has promoted some forest patch coalescence in the montane zone during most of this century." (Ponderosa and Doug-fir, decrease of "natural fragmentation".)
4	Baker	Measuring and Analyzing Forest Fragmentation in the Rocky Mountains and Western United States. Definitions of edge, patch, core areas, corridors, connectivity. • "…no computer software is readily available for analyzing connectivity and there has been no analysis of fragmentation using connectivity indices in landscapes of the western U.S." • Fragmentation effects are greater than the number of acres clearcut, edge effects extend beyond. • Coarse filter approaches could indirectly sustain 85-90% of the species.
5	Baker and R.L. Knight	*Roads and Forest Fragmentation in the Southern Rocky Mountains* Relative Road Density of Wyoming National Forests (miles of road per square mile): • Shoshone: 0.42 • Bighorn: 0.94 • Routt-Medicine Bow: 1.29 • Black Hills: 2.37 Cites conflicting studies on elk hunting and road densities: • N.Central Idaho, probability of elk being killed increased with road and hunter densities. • Two studies showed that closing roads may reduce mortality rates on elk Potential Mitigation/Restorative Measures: • Close roads effectively

Chapter	Authors	Key Findings
		• Minimize impact of new roads by avoiding large interior blocks and by avoiding high value areas, such as riparian, etc. • Design crossings for species needs: amphibian tunnels, pipes.
6	Smith	*Forestry Practices and Forest Fragmentation in the Southern Rocky Mountains* • Forestry practices in this area often shift the successional or structural status of forest, but will not lead to isolation of forest remnants in a matrix of nonforest land use. Where land use is not changed, fragmentation may or may not occur. • In National Forests of Wyoming and Colorado, over 50% of forests originated following disturbances between 1867 and 1927. 10% originated in the last 60 years (1927-1987). • From 1992 to 1996, 0.2% of suitable forest lands and 0.06% of all forested lands in the National Forests in CO and WY received reproduction cuttings annually. • Recent silvicultural practices (small clearcuts) has caused disproportionately large perforation and fragmentation effects compared to the small number of acres harvested. Activities scaled to size and shapes characteristic of natural disturbances will minimize disruption of habitat.
7	R.L. Knight	*Forest Fragmentation and Outdoor Recreation in the Southern Rocky Mountains* • Outdoor recreation is second to water development as the principle cause of species decline in a study on causes of endangerment of federally listed species public lands in US. • General recreation, off-road vehicle use, hiking, boating, and skiing, in that order, are the primary recreation causes of species declines. • Some trail densities for National Forests in CO and WY: ○ Pike-San Isabel: 0.54 km/sq.km ○ Rio Grande-San Juan: 0.26 km/sq.km ○ Bighorn: 0.47 km/sq.km ○ Medicine Bow: 0.13 km/sq.km ○ Shoshone: 0.24 km/sq.km • Ways to mitigate/minimize effects: ○ Place new trails so they parallel existing human created edges, instead of bisecting contiguous undisturbed areas. ○ Avoid important habitats, such as riparian, cliffs, etc. ○ Close or reroute trails ○ Close areas
8	Theobald	**Fragmentation by Inholdings and Exurban Development** Information presented primarily from Colorado, where urbanization of areas that were "wild" a few decades ago is a huge impact. Examples from front range and Summit County. Theobald's population trend maps for Wyoming are included in R2 Terrestrial Ecosystem Assessment report – they predict urbanization of a considerable amount of Sheridan and Johnson counties over the next 50 years, less impact on west side of Bighorns. On National Forest affects of this are generally small, effect is in adjacent, linked ecosystems.
9	Beauvais	*Mammalian Responses to Forest Fragmentation in Central and Southern Rocky Mountains* • Maps of alpine/mountain environments in CO and WY – Bighorn clearly an island habitat. • List of species grouped according to affinity to three habitats: conifer forests, open vegetation and several vegetation types. • Background of landscapes since last ice age: 10,000 years ago, Bighorn

Chapter	Authors	Key Findings

		mountains were alpine/above tree line; Great Plains were mostly subalpine spruce/pine forests.
		• Review of literature by species of relationships between microhabitat structures and mammal abundance and use.
		• "Responses of mammals to human-caused fragmentation of forests in Central and Southern Rocky Mountains are poorly understood."
		• Comment on Tinker, et al (1998): clarifies current and local relationships, but tends to ignore historical and regional processes.
		• Legal hunting mortality on game species is positively correlated with road density (Unsworth, et al, 1993) central Idaho – Clearwater NF
		• Recommendations for timber harvest:
		  o Reduce clearcutting
		  o Retain important structure, like logs, CWD
		  o Minimize impact in spruce-fir forests
		  o Cluster clearcuts and mimic natural disturbance processes

10	Hansen, Rotella	**BIRD RESPONSES TO FOREST FRAGMENTATION** • Initial studies in eastern hardwood forests showed fragmentation effects on bird species; however, forests in Rocky Mountains are much more naturally fragmented because of interspersions of grasslands and shrublands. • Analysis shows that birds of Southern Rockies are less sensitive to forest fragmentation and more sensitive to lack of natural disturbance (such as wildfire) that bird communities in the Northwest and Eastern US. • Logging could lead to reductions in some species abundances and ultimately to local extinctions; however, the influence of forest spatial configuration on native birds here appears to be rather weak. No species yet identified that are obviously sensitive to forest spatial configuration. • Fire suppression and increasing forest cover and density in some habitats could also have effects, although current data and linkages are weak. • Rural residential development is often in places in the landscape that are hotspots for native species abundance and richness. • Excellent opportunites exist to use prescribed fire and ecological forestry to expand the area of aspen groves, grasslands, and early successional, structurally complex seral stages.

11	Baker, Dillon	**PLANT AND VEGETATION RESPONSES TO EDGES IN THE SOUTHERN ROCKY MOUNTAINS**
		• Disturbances (blowdowns, grazing, etc.) may be different along edges
		• "Matrix effect": Openings adjoining the edge may affect propagule rain and disturbances reaching into the matrix.
		• Higher order effects (direct effects upon plants or animals that indirectly affect other species) have not been studied.
		• There have only been a few studies in the western US on edge effects:
		  • A study on roads and the depth of the edge influence (DEI) found:
		    • Road edges are different than clearcut edges, DEI > on CCs than roads
		    • Stem density, BA, mean dbh did not change on road edges
		    • More Lodgepole regeneration along road edge than interior
		    • Different species: exotic and non-natives planted
		    • Exotics were edge restricted, did not extend into matrix/interior.
		• What to do to minimize edge effect:
		  • Concentrate harvest area, rather than disperse: less edge
		  • Avoid Clearcuts in high windthrow risk areas, so they don't "grow.
		  • Plant natives at edges
		  • Conduct harvests, such as selection, that do not create edges
		  • Several questions remain: rate of "seal", recovery, higher order effects.

Chapter	Authors	Key Findings
12	Ruefenacht, Knight	**SONGBIRD COMMUNITIES ALONG NATURAL FOREST EDGES AND FOREST CLEAR-CUT EDGES** No previous studies did this; this study on AR NF in Colorado in lodgepole. • Bird species more abundant along natural edges vs. CC edges • Bird species abundance not different between forest interior adjacent to natural openings compared to forest interior adjacent to clearcuts. • First finding different than Keller and Anderson, 1992 on Med Bow. They studied effects of fragmentation on birds, found little evidence that any species either used or avoided natural edges vs. clearcut edges. • For natural nests: found that predation rates and # of birds fledged were independent of distance of nest to edge. • For artificial nests: 1995 data: predation in interiors and edge of natural openings less than near clearcut edges. 1994 data: no difference observed.
13	Carter, Gillihan	*Influence of Stand Shape, Size and Structural Stage on Forest Bird Communities in Colorado* *Study in spruce fir and mixed conifer forests in Rio Grande NF* • Shape: Western tanager only species studied that responded to shape. Negative abundance to amount of edge (conclusion was more due to structural characteristics of stands than shape.) • Patch Size: Some species (ex: robin, dark eyed-junco) favor small patches; others (red-breasted nuthatch) favored medium sized patches. • Structural stage is important, species have definite affinities, much more so than patch shape or size. • Need to learn about adjacency requirements for species, ex. HSS 1 next to 4…
14	Lowsky, Knight	**EFFECTS OF WILDERNESS DESIGNATION ON THE LANDSCAPE STRUCTURE OF A NF** Study: AR, Colorado: is landscape pattern and structure different between a protected landscape and the multiple use NF lands in which it is embedded? Are protected landscape composition and configuration more suitable for the persistence of those species most sensitive to habitat alteration? If so, protected areas may be disproportionately more important in persistence of biological diversity. Findings: Wilderness had more: • Rock, ES/AF, Late seral successional stages (matrix dominated by mid-seral) • Larger patch size (except doug-fir); more large patches • More core and less edge • Less early seral stages, speculated due to lack of disturbance processes.
15	Shinneman, Baker	**IMPACT OF LOGGING AND ROADS ON A BLACK HILLS PONDEROSA PINE FOREST LANDSCAPE** (cursorily summarized here) Little old-growth left; lots of small, young patches; lots of edge; little core.
16	Tinker, Baker	*Using the LANDLOG Model to Analyze the Fragmentation of a Wyoming Forest by a Century of Clearcutting* • Computer simulation of 100 year application of 1985 Forest Plan timber harvest on Med Bow. Used 1985-1994 as baseline, 87.4 clearcuts per year and 6.23 hectares per clearcut. Applied spatial standards and guidelines. • Huge increase in number of patches; % of landscape in large patches decreased; Core area decreased; Edge to core area ratio increased • Mean age in 1997 = 98; in 2097 was 85. • "Stands of lodgepole in Bighorns clearcut in the 1950's have changed relatively little since harvesting." Gary Beauvais, personal communication

Chapter	Authors	Key Findings
		• Computer seemed to indicate this rate of harvesting was sustainable, but they listed a bunch of questions as to whether that was really true. • Bottom line: clearcutting as practiced between 1985 and 1994 produces highly fragmented landscapes.

17	Aplet	**A LANDSCAPE APPROACH TO MANAGING SOUTHERN ROCKY MOUNTAIN FORESTS**
		• Best strategy for future: natural. The most whole, possess all components of the ecosystems that historically dominated the land. The conditions that sustained species and other ecosystem components in the past are the conditions most likely to sustain those same components in the future.
		• Great definition of Composition: abundance of ecosystem components, such as plant and animal communities, water, and nutrients; Structure: physical distribution in space; Function: processes through which composition and structure interact, including predation, decomposition, and disturbances such as windstorms and floods.
		• Pattern management disturbances after natural disturbances:
		  • Determine historic composition, structure, function
		  • Assess current conditions
		  • ID areas least departed from historic/natural conditions and those elements of the ecosystem that are rare/threatened.
		  • Protect those places from further degradation
		  • Develop methods for moving altered landscapes toward natural conditions
		  • Test methods on a portion of the landscape
		  • Implement restoration on the degraded landscape using adaptive management framework.

18	Romme, Floyd, Hanna, Redders	*Using Natural Disturbance Regimes as a Basis for Mitigating Impacts of Anthropogenic Fragmentation* Suggestions on how management related disturbances can be designed to mimic natural disturbances to which the systems are adapted to minimize effects upon species. • Long history or natural disturbance, disrupted by people • Very heterogeneous landscape in Rockies, different regimes/patterns • Cultural landscape, we currently manage systems that are a legacy of those who have gone before us, recently and historically. • Knowledge currently is not perfect – must adopt adaptive mgt. philosophy • Long discussion of Ponderosa Pine, low elevation situation and ecology. Pines project as example of restoration applied – complicated, expensive. • High Elevation LP/ES/AF/Aspen. Disturbances long interval, lethal. Some I/D • Interruption of fire this century may not be unprecedented. Ex: Bessie and Johnson, long term drought and frontal passages needed for big events. Fires may not be manageable in this regime. • Roads and timber harvest have had unprecedented affect. Clearcuts leave legacy for centuries. • Table lists specific species affects. Slow regenerating clearcuts affects are not all bad; increased streamflow & early successional dependant species habitat. • Intensity of removal of organic matter is unprecedented. Roads bring people and vector for alien species. • Dispersed harvest maximizes fragmentation. • Table of management recommendations, including variable retention strategies and cut aggregation; minimize roads, used prescribed fire.

Chapter	Authors	Key Findings
		• Recommendations: Quantify description of reference conditions; Monitor what must be an "experimental approach" – Adaptive Management
19	Keiter	*Law, Policy, and Forest Fragmentation in the Southern Rocky Mountains* *NFMA, NEPA, ESA primary laws. When applied courts have:* • *Given deference to agency legal interpretations so long as it is consistent with statutory language and congressional intent* • *Tend to defer to agency expertise in reviewing decisions, if based in defensible scientific information and agency responded to contrary scientific opinions* ***NFMA**: amended MUSYA of 1960, reaffirmed multiple use, but required ID team and Forest Plans. Rose other resources to equals with timber, imposed clearcut limits.* *Biodiversity: courts have given FS broad discretion on biodiversity analysis: FS possesses requisite scientific, technical experts. FS not required to incorporate conservation biology principles into Forest Plan biodiversity analysis.* *Species Viability: Population distribution and habitat protection requirements designed prohibit fragmentation that threatens viability of forest dwelling species. Must do at project and Forest Plan level. FS does not have to select alternative that provides highest likelihood of species survival. Courts have deferred to agency expertise on pop. viability analyses. Viability requirements have not been an "absolute prohibition on forest fragmentation."* *PNV**:** If decision is to select an alt. with a comparatively low PNV, NFMA requires explanation of why that alt. chosen over one with higher PNV.* *Roads: No explicit requirements under NFMA for roads. FS does have authority to close roads and areas to off-road travel.* ***NEPA:** FS must analyze impacts of proposed timber sales on WL corridors connecting sale areas. NFMA does not require FS to ensure connectivity in Forest Plans; rather can address connectivity in project level min. viable population. Cumulative effects must include adjacent lands of other ownership; however, don't have to extend min. viable population analysis off-forest.* ***ESA:** Limited application to date in Rockies, few species listed: Mex. Spotted Owl, Lynx, Goshawk (proposed).* • *Timing of judicial review, given regional, Forest Plan and site specific project planning levels: Generally, Supreme Court has said that since forest plans may be amended, and are elaborate documents covering diverse lands, wait until specific timber sales with specific assessments before reviewing NFMA claims.* Ohio Forestry*: timber probably not ripe in Forest Plans. If plans contain specific road decisions, more likely to be ripe for prompt judicial review. More interpretation to come.* • *Multiple levels of planning require some discussion of effects (frag, etc) at the different planning scales.* • *Adaptive management: Inventory and monitoring is obligatory under NFMA, case law says I&M only necessary when technically and financially feasible. Citations to Texas rulings on habitat monitoring alone is not sufficient for MIS.* • *Review of collaboration and public involvement in ecosystem management.*
20	Romme, Knight, Baker, Smith, Buskirk	*What have we learned about Forest Fragmentation in the Southern Rocky Mountains?* • *Despite that fact that Rocky Mountain forests are naturally "fragmented" due to natural heterogeneity, fragmentation is a serious issue since anthropogenic land uses have created a "new kind of fragmentation within an already patchy landscape".* • *We can analyze quantitatively; projections show little old, interior forest could remain in future in parts of Rockies if management does not consider this*

Chapter	Authors	Key Findings
		issue. • *Effects are known on some species.* • *Effects are unknown on soil fungi, bacteria, invertebrates, reptiles, amphibians, etc. No research out there.* • *Appears that no vertebrate or vascular plant species has been extirpated from S. Rockies due to fragmentation (perhaps lynx) however, don't know long-term effects of what has happened in past few decades.* • *So far, logging, roads, exurban development implicated. Trends changing, other villains may emerge: Jackson, recreation, subdivisions. Need to monitor and update threats as develop.* • *"Given our general lack of knowledge about the long-term effects of anthropogenic fragmentation of Rocky Mtn. Forests, and some of our past experiences, we urge managers to be conservative and cautious when they contemplate new, intensive land uses for the 21st century."*

SOME CONCLUSIONS ON "FRAGMENTATION ON THE BIGHORN NF"

- **Some areas of the Bighorn National Forest have had structural changes to the forest matrix caused by timber harvest and road construction.** These changes have included conversion of mature forests to early successional forests and changes in patch size and density. These changes were quantified in Tinker, et al (1998).
- **Mammals studied on the Bighorn National Forest have specific structural affinities (Beauvais, 1997).** Species such as weasels and coyotes are more often found in early structural stages or a mix of structural stages, while species such as southern redbacked voles, moose, and martens are strongly associated with undisturbed, late successional forests.
- **Merrill (1997) found that "…landscape heterogeneity was generally a more important indicator of bird diversity in the [Bighorn National Forest] at the scales we studied than indices related to patch size or isolation or edge characteristics." Other research not on the Bighorn NF has found that, like mammals, avian species have specific habitat affinities.**
- **The chapter 20 summary in the table above fits the information that has been collected on the Bighorn NF to date.** Some important revision considerations may be to:
    - Consider natural disturbance regimes, disturbance patterns, sizes, frequencies and intensities in designing projects that affect the landscape matrix.
    - Consider effects from fire suppression, such as the homogenization of low elevation forests.
    - Develop and implement a monitoring program that will continue to build our knowledge base on this topic.